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APPROVED		
CHECKED		
PREPARED: S. Yamazaki	LAND BASED TEST REPORT	
DRAWN		
DATE		

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KORDI
Korea Ocean Research & Development Institute

TEST REPORT

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Title

Final Test Report for the Type Approval of the "FineBallast" Ballast Water Management System

Customer MITSUI ENGINEERING & SHIPBUILDING CO., LTD.	Project No. PI55270
Administration Ministry of Land, Transport and Maritime Affairs, Republic of Korea	Project Manager Shin, Kyoungsoon
Test Items Land-Based Test According to Guidelines for Approval of Ballast Water Management Systems(G8) of IMO	Date 1st May 2011

Summary:

The land-base testing of the type approval of the "FineBallast MF" ballast water management system (MWMS) has been conducted according to provisions in the Guidelines for approval of Ballast Water Management Systems (G8) and the Procedure for Approval of BWM systems that make use of Active Substances (G9). When testing is performed for the final approval of a BMWS that makes use of active substances, the final test report has to be reported to the government and disclosed to people. All the tests reported herein have been implemented under a quality assurance system that complies with ISO/IEC 17025, a provisional standard concerning the type approval of BWMS.

Project Manager : _____

Shin, Kyoungsoon

Contents

1. Introduction

The South Sea Institute of KORDI is approved by the Korea Laboratory Accreditation Scheme as a test laboratory capable of conducting analyses on aquatic organisms. according to provisions in ISO/IEC17025. All tests performed for the verification of effectiveness are performed under a quality assurance system that complies with ISO/IEC 17025. KOLAS is an organization approved by the Republic of Korea. KOLAS makes judgments about the technical properness at test and calibration test laboratories in view of general requirements including the appropriateness of tests performed in various areas according to KOLASはISO/IEC17025, the requirements concerning calibration test laboratories and special technical requirements.

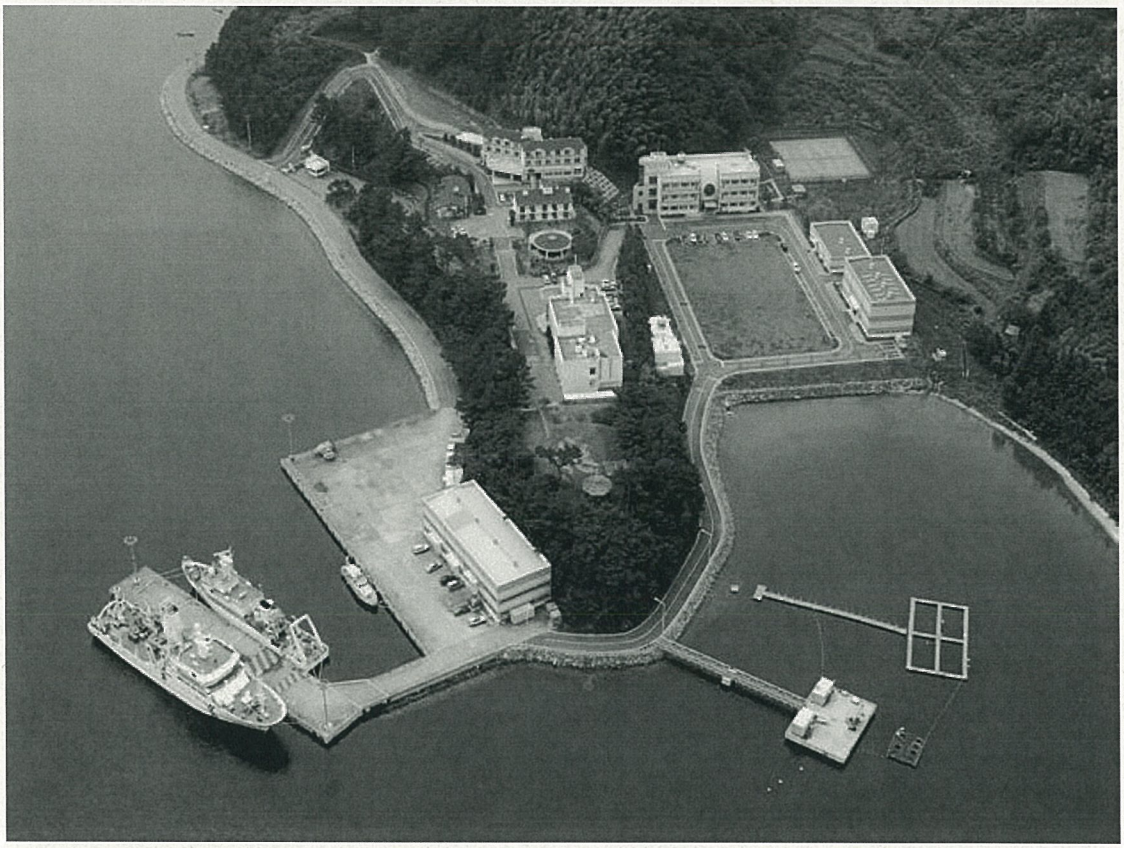

Fig. 1.1 South Sea Institute of KORDI

The Guidelines (G8) contain provisions on the design and engineering related general requirements that must be satisfied as a condition for the issuing of a BWMS type approval certificate as well as provisions on the technical procedures for to be followed in the evaluation process. The Guidelines (G8) demands that the type approval of BWMS be based on both shipboard testing and land-based testing. In this sense, the type approval of BWMS has particularities that distinguish it from the type approval of conventional equipment for installation on ships.

2. Land-based Testing

The Guidelines (G8) demand that the land-based testing be performed for two test cases that differ in the salinity of water by 10PSU at least. The land-based testing was performed a the port facility of the South Sea Institute of KORDI, located in the south of the Korean Peninsula.

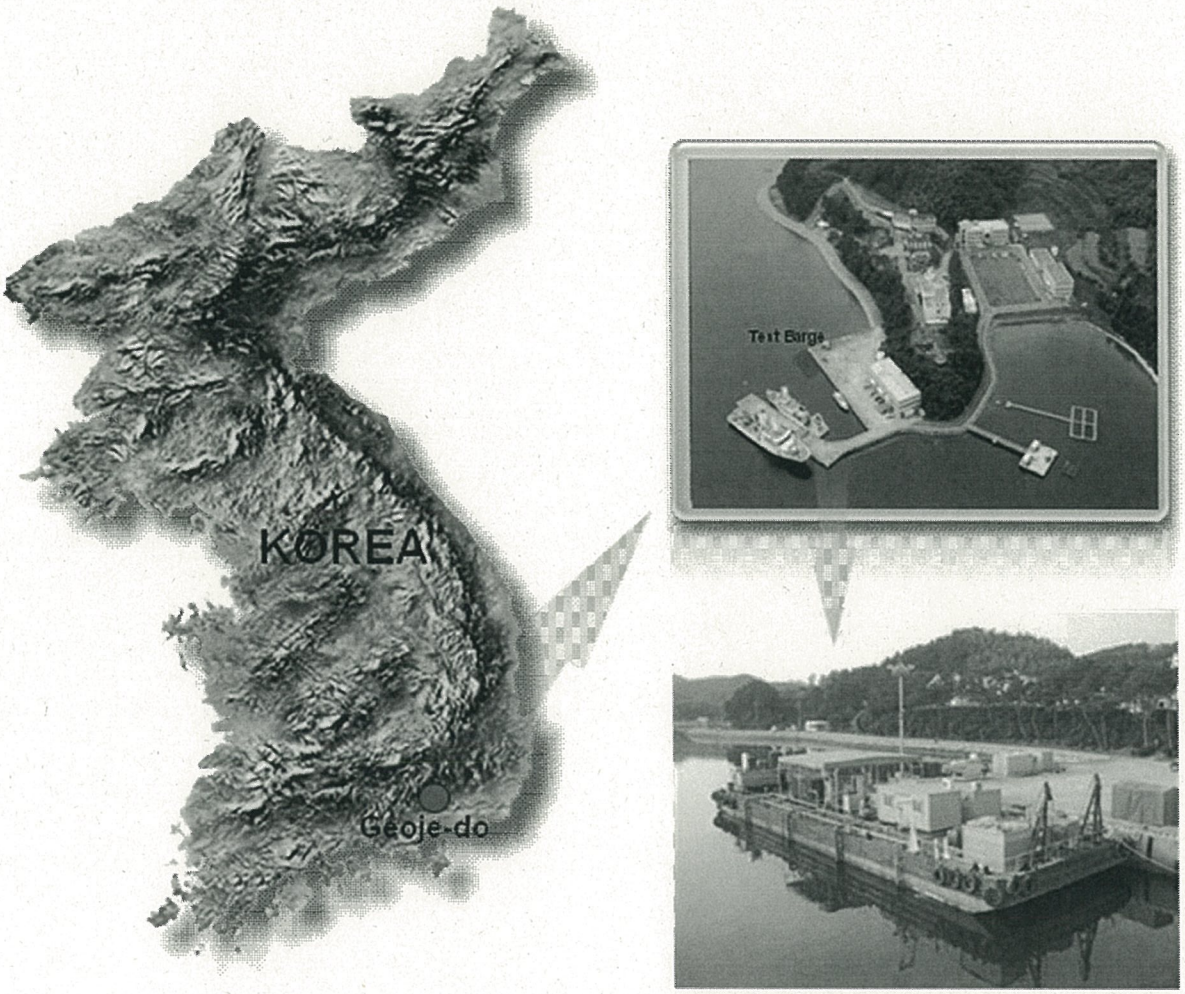

Fig. 2.1 Test barge in harbor of South Sea Institute, KORDI

The KORDI performed all the tests with a view to demonstrating compliance with Regulation D-2. The KORDI successfully performed the land-based testing by completing five test cycles with seawater and also five test cycles with brackish water.

2.1 Information about the test barge

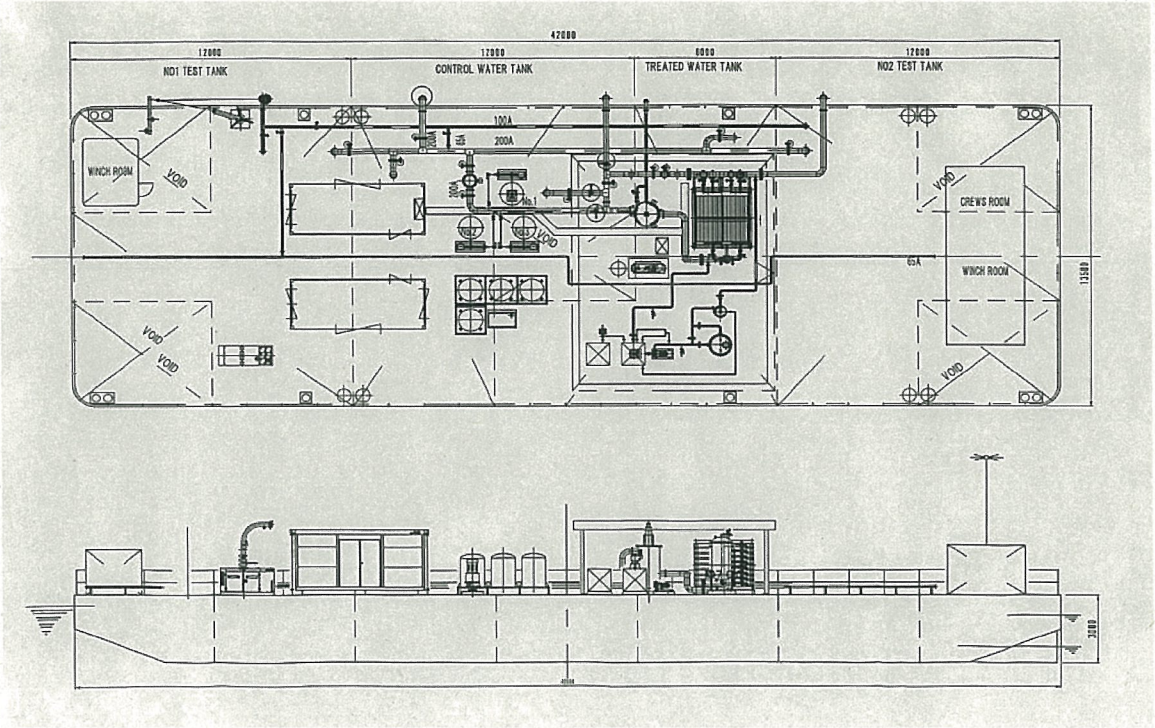

Fig. 2.4 the barge for land- based test

2.1.1. Specifications of the "FineBallast MF" system

Refer to MEPC 61/23 document.

2.2. Installation and sampling procedure on the barge

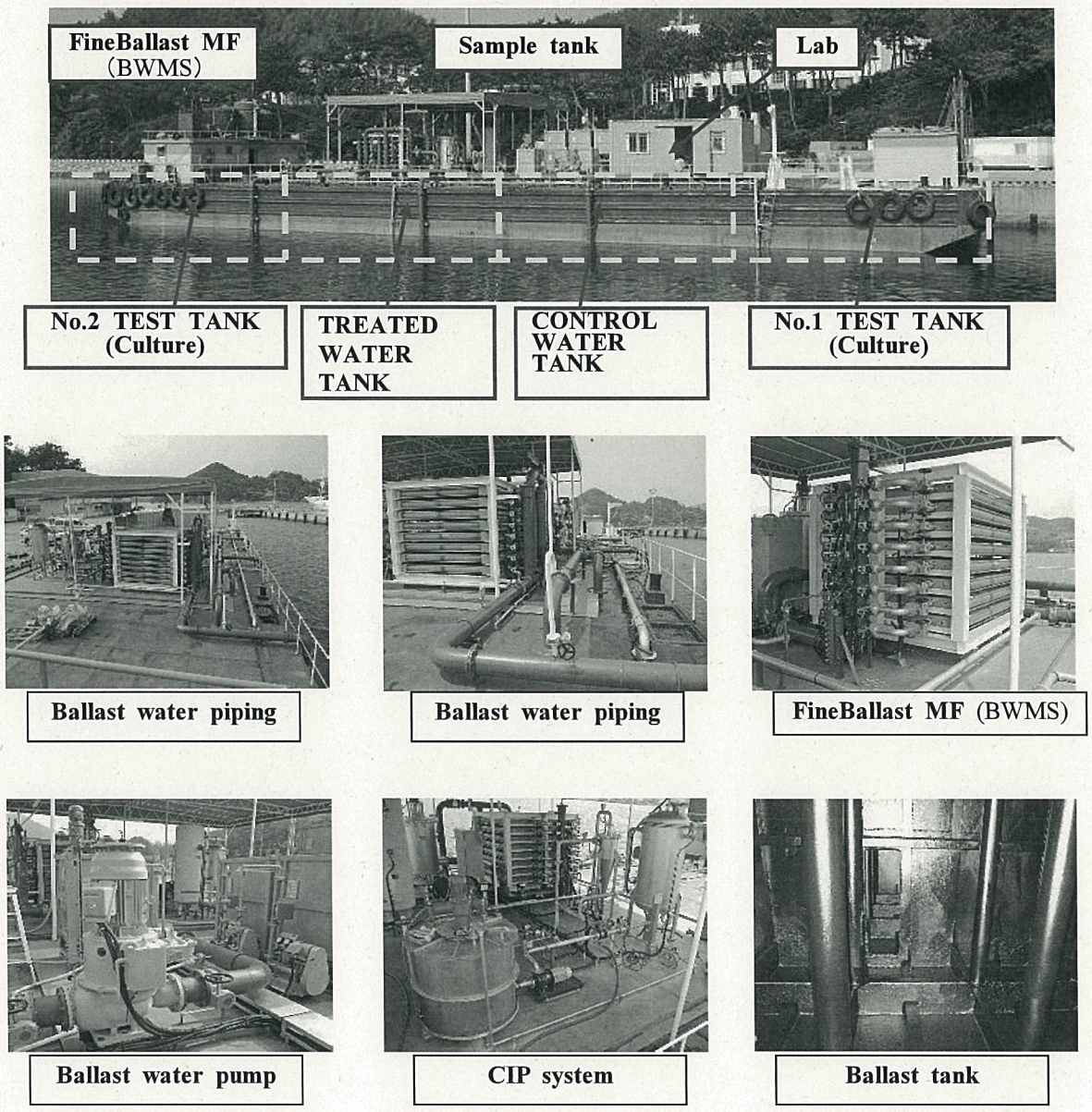

Fig. 2.5 Description of the barge for land-based test

The sampling procedure is as follows (Fig. 2.6, Table 2.1)

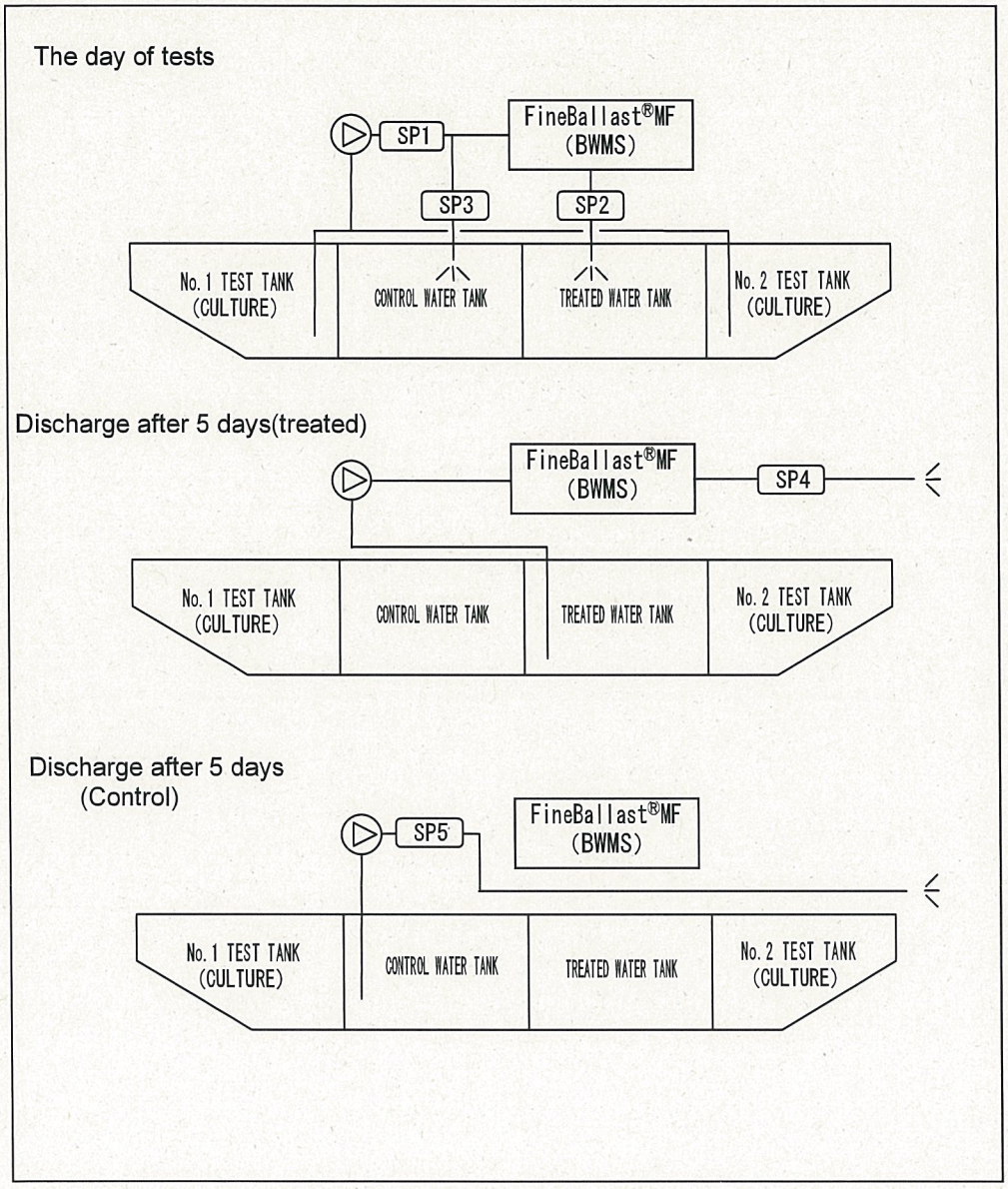

Fig. 2.6 Test piping diagram and sampling point for Land-based test

Table 2.1 Sampling procedure

Procedure	**Water Flow**	**Sampling Point**
Uptake from sea chest	Strainer > Pump > Tank 1, Tank 2	
Uptake from tank, treatment and store at treated and control water tank	Tank 1 and Tank 2 > Pump > Parallel (Treated/Control Line) T.L > Treatment > Treated water tank C.L > Control water tank	SP1, SP2 SP3
Discharge of treated water	Treated water tank > Pump > Treatment > Outlet	SP4
Discharge of control water	Control water tank > Pump > Outlet	SP5

2.3. Preparation for the test

2.3.1. Cleaning the tanks and pipes

Fresh seawater pumped from the sea is used to purge the existing seawater and sediments away from the ballast tanks. In addition, each ballast tanks is washed using pressured clean demineralized water after the completion of each test. (See Fig. 2.7.)

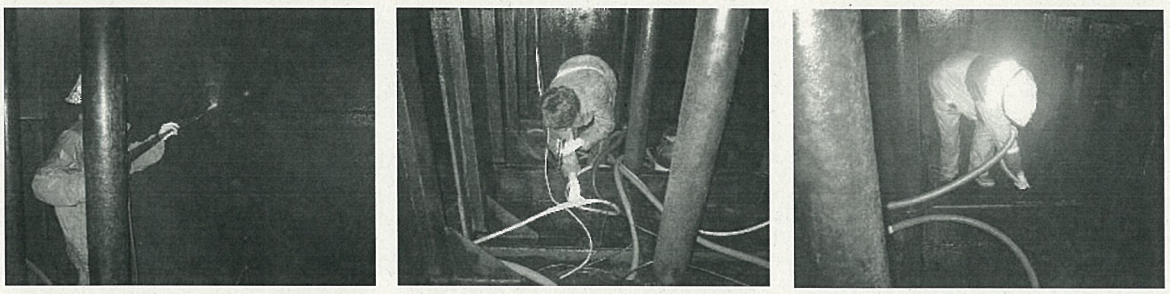

Fig. 2.7 Tank cleaning

2.3.2. Test water

The water used in the tests was high salinity seawater from Jangmok Bay or brackish water prepared by adding tap water to seawater from Jangmok Bay to obtain the required salinity. One thankful of seawater (salinity above 32 PSU) and one thankful of brackish water (salinity in the 3-to-32 PSU range) were prepared, making up the total of about 440m^3 (tank capacity 220m^3 x 2 tanks), ensuring that the seawater and brackish water differ in salinity by 10PSU at least. Tap water was added in the preparation of brackish water after the bubbling of about one day for the removal of any residual chlorine. The 440m^3 of test water served as the source of the treated water as well as the source of the control water.

The water quality demanded by the Guidelines (G8) in terms of biological conditions was achieved by the presence in water of local species of aquatic organisms and the addition of cultured organisms (*Artemia salina* as a species of organisms greater than or equal to 50μm in minimum dimension; *Scrippsiella trochoidea* and/or *Tetraselmis sp*. as a species of organisms greater than or equal to 10μm but less than 50μm in minimum dimension). As to the initial concentration levels of dissolved organic carbon (DOC), particulate organic carbon (POC) and total suspended solids (TSS), the conditions demanded by the Guidelines (G8) were produced by the addition soluble glucose, seaweed powder and prepared mud.

2.4. Test methods

The nets used for increasing the concentration of organisms at the sampling site strictly grouped into three sets in order to prevent secondary contamination. [Each set combines two types of net with different mesh sizes: 7μm and 45μm (diagonal measurement).]

2.4.1. Temperature and salinity

The water temperature and salinity were measured using YSI6600 Multi-parameter Water Quality Sonde. The probe of this instrument has been calibrated annually by the manufacturer.

2.4.2.pH

The pH was measured using a Model 1230 pH meter from Orion Research Inc. The pH meter was calibrated using standard solutions (Orion application buffer: pH4, 7 and 10) before each test according to the manufacturer's guidance.

2.4.3. Dissolved oxygen

The dissolved oxygen (DO) was measured using YSI6600 Multi-parameter Water Quality Sonde. An optical DO sensor attached to the YSI6600 instrument was calibrated before measurement-taking according to the manufacturer's guidance. The maintenance servicing of the instrument has been done at the interval of three months or less.

2.4.4. Determination of dissolved organic carbon (UNESCO, 1994)

In the analysis of dissolved organic carbon, each seawater sample is filtered using a 25mm-size Whatman GF/F filter (nominal pore diameter: 0.7μm) that has been heated (450 degrees C, 2 hours). Then 20mL of the filtered sample was collected into a 30mL EPA vial (Wheaton, WH.W227354) that had been heated. Promptly after thus being collected, the filtered seawater sample was acidified using a 10% H_3PO_4 solution and was exposed for 10 minutes to ultra-pure oxygen that was made to fill the vial for the removal of dissolved inorganic carbon (DIC). Next, 100mL of DIC-removed secondary sample was injected into the combustion tube of a total organic carbon analyzer (Shimadzu TOC-VCPH), filled with platinum catalyst activated at 650 degrees C, to achieve the oxidization of DOC into CO_2. The separated CO_2 was measured using an infrared sensor. The measurement was completed in the same day and the three-point calibration curve was produced using a potassium phthalate standard solution newly prepared using Milli-Q water. This standard analysis procedure was performed once a day, selecting the DOC measurement range of 10mg/L. All DOC values reported here in are the average of three measurements performed on the same sample (per JGOFS, 1994).

2.4.5. Determination of particulate organic carbon (UNESCO, 1994)

Water sample for the analysis of particulate organic carbon (POC), was prepared by putting the sampled water firstly into a sterilized 2L-size container. The 200mL of seawater sample was filtered using a 25mm-size Whatman GF/F filter (nominal pore diameter: 0.7μm) that has been heated (450 degrees C, 2 hours). During the filtering process, a vacuum (0.0027Mpa or 200torr) was created inside the container slowly so that cells caught by the filter may not rupture. After the filtering, the wet filter was removed from its holder and then kept in a quick freezer (-20 degrees C). Before analysis, the filter was removed from the freezer and kept in a desiccator saturated with hydrochloric acid vapor for one night. The atmosphere inside the desiccator was kept saturated with hydrochloric acid vapor by placing at the bottom of the desiccator an open container filled with highly concentrated hydrochloric acid solution. After that, the filter was again left to dry for two days at 65 degrees C. Immediately before analysis, the dried filter was placed on a palette with aluminum foil using a pair of tweezers (Sharp, 1974). The concentration of POC on the dried filter was measured using a CHN elemental analyzer EA1112 from ThermoQuest (JGOFS,1994).

2.4.6. Determination of total suspended solids (APHA, 1995)

A 47mm-size Whatman GF/F filter (nominal pore diameter: 0.7 μm) was rinsed three times using 20mL of distilled water and then dried for an hour at the temperature of 103 to 10degrees C. After that, the filter was cooled by being exposing it to the room temperature in a desiccator for 30 minutes. Then the filter was reweighed. The volume of the sample water that was made to pass through the filter in the next step was adjusted with a view to leaving the solids of 10-200mg in the filter. If the quantity of TSS in the sample water was too small (10mg/L or less), measurement was to be performed using a high precision scale (0.001mg class) to compensate for the smallness of weight. An appropriate volume of the sampled water was then made to pass through the 45mm-size Whatman GF/F filter. Solids on the filter were dried at the temperature of 103 to 105 degree C for an hour. After that, the filter was cooled by being exposing it to the room temperature in a desiccator for 30 minutes. Calculating the difference of the filter weight between the first and second measurements and dividing it by the sample water quantity (L), the concentration of TSS was determined.

2.4.7. Viability test of organisms

- Organisms greater than or equal to 10μm but less than 50μm in minimum dimension

The capability of the "FineBallast MF" BWMS in killing organisms greater than or equal to 10μm but less than 50μm in minimum dimension (mostly planktons) was evaluated by three different modes of observation supported by optical microscope, incident-light fluorescence microscope and fluorometer (Turner Designs 10-AU). With an optical microscope, the aliveness of phytoplanktons, for example, is confirmed by the observation of their coasting movement or any other self-initiated movement. The autofluorescence of chlorophyll can also serve as an indicator or the aliveness of cells (Pouneva, 1997). Wholesome chlorophyll in living cells show a red fluorescence while dead or badly injured cells do not. Normally, when observed using an incident-light fluorescence microscope with a green filter, most parts of living cells appear in bright red while dead cells appear in faint green or appear without any red fluorescence. A highly sensitive fluorometer can detect fluorescence from living phytoplanktons existing at the concentration of one or more organisms per 1mL. therefore, a failure to detect any fluorescence using a fluorometer can be interpreted as the perishing of all cells. Any slight detection of fluorescence, on the other hand, indicates the presence of living cells in the sampled water. During the examination, a fluorometer was used as a complementary means. It should also be noted that the identification of viable organisms f greater than or equal to 10μm but less than 50μm in minimum dimension was facilitated by the use of the fluorescent diacetate (FDA) staining method.

-- FDA staining method

A diluted FDA solution was prepared by adding dimethylsulfoxide (DMSO) at the concentration of 5mg/mL according to the method of Gervey et al. (2007). FDA was available in the market as a product from Sigma. The diluted standard FDA solution was kept in a refrigerator (at 7 degrees C that is below the DMSO freezing point). A solution for use in experiments was prepared every day by thawing it (Jochem,1999). The standard diluted solution for normal use was prepared by adding the DMSO in its initial state to cold distilled water (50 μg/mL), diluting it by 100 times. The diluted standard solution was stirred continuously in a dark cold place during the preparation period in order to prevent precipitation. Each sample was stained by the addition of 100μL of the diluted standard solution per 3mL of sample water (final concentration: 1.7 μg/mL FDA). Each stained sample was kept in a dark cold place for at least 10 minutes before the counting of organisms. If kept in an ice bath in a dark place to prevent the loss of fluorescence, the sample remains suitable for observation for as long as 90 minutes.

-- Counting of organisms facilitated by the FDA staining method

Gervey et al. have described the method of counting FDA-stained phytoplanktons using an incident-light fluorescence microscope. FDA-stained pieces of cells (organisms) can be identified using an incident-light fluorescence microscope at a magnification factor between 100 and 400 depending on their size. Organisms resembling minute planktons but show only a green fluorescence (wavelength: 520-530nm), do not move on their own and is devoid of red autofluorescence should be regarded as heterotrophic organisms except in some special cases of excitation with a blue light (wavelength: 450-500nm).

- Organisms greater than or equal to 50μm in minimum dimension

As to organisms greater than or equal to 50μm in minimum dimension (mostly zooplanktons), their viability was determined by observing the movement of the organs they have using a stereoscopic microscope (APHA-804C, 1985). Since organisms are classified into different groups, the counting of living and dead organisms was done on a group-by-group basis. Zooplanktons were judged as being alive if they moved around actively or made an attempt to run away when poked by a thin needle. They were considered dead if they did not react at all even after being poked several times by a thin needle. Viability testing was performed only on wholesome zooplanktons. The scope of application of this evaluation method extended to non-self-moving organisms greater than or equal to 50μm in minimum dimension.

-- Counting of heterotrophic bacteria facilitated by the DAPI staining method:

Since the sampled water condition had to be stabilized, 50mL of seawater was fixated using neutralized formalin (final concentration: 2-4%). Each 1mL sample of sufficiently fixated seawater was stained using 2mL of a diluted standard solution of DAPI (6-diamidino-2-phenylindole). After five minutes, a fluorescence microscope was applied with an UV filter at the magnification factor of 1000 to perform the

counting of organisms in at least 10 sections.

- Indicator bacteria

-- Colon bacillus (Escherichia coli)

After passing a 10mL seawater sample through a membrane filter (pore size: 0.2μm), the filter was placed on a counting plate for *E. coli/ Coliform and Coliform* (a Petri dish from3M™). For culturing, the Petri dish was kept at the temperature of 35 degrees C for 24 hours. Colonies of Escherichia coli would appear on the Petri dish as blue or purple bluish spots (of a corresponding size) showing a sign of bonding with the charged gas. With each sample, counting was repeated for eight to ten times.

-- Vibrio cholerae (serotypes O-1 and O-139)

After passing a seawater sample of 5-10mL through a membrane filter (pore size: 0.2μm), the filter was placed on a Thiosulfate Citrate Bile Sucrose (TCBS) nutrient agar plate. After necessary preparations, the TCBS agar plate was kept at the temperature of 35 degrees C for 24 hours for culturing. If green spots appeared, they were regarded as colonies of Vibrio parahaemolyticus. A part of the nutrient agar where yellow colonies grew was separated and kept at the temperature of 35 degrees C for 24 hours for culturing. If the cultured colonies had a purple color, a positive judgment was placed. Otherwise (including the case of only partially purple), a negative judgment was placed. If the cultured colonies were judged positive, an API20E test was performed. If the colonies had appeared partially purple in this test, further examination would have been required because it suggested the possibility of Vibrio cholerae being present. However, no such colony was found in the API20E test. With each sample, counting was repeated for eight to ten times.

-- Intestinal Enterococcus

After passing a 20-40mL seawater sample through a membrane filter (pore size: 0.2μm), the filter was placed on an agar plate for the culturing of intestinal Enterococci. After necessary preparations, the agar plate was dried at the temperature of 35 degrees C for 48 hours. Pink or brown spots of 0.5-2mm in diameter that appear as a result of this process are usually the colonies of intestinal Enterococci. With each sample, counting was repeated for eight to ten times.

-- Heterotrophic bacteria

Heterotrophic bacteria were cultured using R2A nutritional agar and counted by the plate smearing method. The sample was smeared onto five or more appropriately dried agar plates. The culturing temperature was selected flexibly in the range between 20 and 25 degrees C In consideration of seawater temperature at the time of sampling. However, the selected culturing temperature had to be maintained without allowing any fluctuation beyond +/-0.5 degrees C. The culturing period was selected flexibly within the range between two days and seven days. A series of tests had to be conducted under the same conditions. At the end of the culturing period, the counting of colonies was performed immediately. Since a plate having 20 to 200 colonies on it but is devoid of any dispersed colony was preferable, counting was performed only on such plates. The number of bacteria per 1mL was determined from the number of colonies per plate and the volume of the sample water.

Finally, comparative experiments for the above tests were performed using sterilized distilled water inn order to verify the absence of contamination during the tests.
Tables 2.2 and 2.3 show the quality of water prepared for use in the land-based testing of the BWMS:

Table 2.2 Information about the quality of water prepared for use in the land-based testing of the BWNS (>32PSU water from Jangmok Bay; standard deviations given in parenthesis)

	S-1	S-2	S-3	S-4	S-5
Salinity (PSU)	32.3 (±0.09)	32.3 (±0.06)	32.4 (±0.05)	32.3 (±0.00)	32.2 (±0.04)
DOC (mg/L)	2.8 (±0.14)	2.3 (±0.07)	2.8 (±0.19)	3.2 (±0.48)	2.9 (±0.12)
POC (mg/L)	1.5 (±0.20)	1.4 (±0.11)	1.8 (±0.08)	2.0 (±0.12)	1.8 (±0.41)
TSS (mg/L)	37.7 (±19.08)	20.1 (±1.10)	25.8 (±4.16)	18.8 (±2.72)	18.7 (±2.21)

Table 2.3 Information about the quality of water prepared for use in the land-based testing of the BWNS (brackish water at 3-32PSU prepared using seawater from Jangmok Bay; standard deviations given in parenthesis)

	B-1	B-2	B-3	B-4	B-5
Salinity (PSU)	21.1 (±0.13)	21.7 (±0.18)	21.2 (±0.07)	21.4 (±0.06)	20.5 (±0.08)
DOC (mg/L)	5.8 (±0.40)	7.0 (±0.22)	5.7 (±0.67)	6.2 (±0.18)	5.5 (±0.26)
POC (mg/L)	5.9 (±1.15)	5.2 (±0.30)	6.2 (±0.73)	6.2 (±0.95)	5.3 (±1.65)
TSS (mg/L)	54.0 (±15.07)	74.4 (±8.96)	79.1 (±18.07)	56.3 (±3.38)	59.4 (±7.93)

2.5. Test results

2.5.1.S-1 (seawater)

The concentration of water samples for biological analyses conducted during the land-based testing of the BWMS was adjusted according to provisions in the Guidelines (G8). Table 2.4 gives water quality data. As shown in Table 2.5, the concentration of L-size group organisms (greater than or equal to 50μm in minimum dimension) in the test water was in the range between 127,050 and 165,625 inds/m^3, while the concentration of S-group organisms (greater than or equal to 10μm but less than 50μm in minimum dimension) in the test water was in the range between 1,248 and 1,534 inds/mL. As shown also in Table 2.5, the concentration of heterotrophic bacteria in the test water was in the range between 1.1 and 1.5 (x10^7 inds/mL). However, both the treated water (pre-treated upon the uptake) and the control water (not pre-treated upon the uptake) passed the criteria concerning the concentration of biological constituents as given by Regulation D-2 after being treated by the "FineBallast MF" BWMS.

Table 2.4. Water quality data from test S-1.

Date	Sample	pH	Temp. (°C)	Salinity (PSU)	DO (mg/L)	TSS (mg/L)	DOC (mg/L)	POC (mg/L)	Turbidity (NTU)
2010.05.26	Test water	7.9	21.6	32.3	6.6	37.7	2.8	1.5	11.4 (±7.03)
2010.05.31	Control	8.0	17.3	32.3	8.3	18.3	2.9	1.5	2.16 (±0.57)
2010.05.31	Treated	8.0	17.8	32.1	7.1	13.1	2.8	0.4	1.21 (±0.21)

Table 2.5. Biological efficacy of "FineBallast MF" from land-based test S-1.

Date	Sample	Sampling at	50μm< (inds/m^3)	10~50μm (inds/mL)	Heterotro. Bacteria (inds/mL)	Heterotro. Bacteria (cfu/mL)	*E. coli* (cfu/100 mL)	*Vibrio cholerae* (cfu/100 mL)	*Enterococcus* (cfu/100 mL)
2010.05.26	Test water	20%	133,902	1,534	1.5E+07	147	53	ND	8
		50%	127,050	1,465	1.1E+07	207	83	ND	3
		80%	165,625	1,248	1.2E+07	193	110	ND	6
2010.05.31	Control	20%	791	121	-	47	13	ND	12
		50%	1,417	117	-	67	ND	ND	53
		80%	1,248	94	-	20	3	ND	208
2010.05.31	Treated	20%	ND	ND	-	10	ND	ND	ND
		50%	ND	ND	-	3	ND	ND	ND
		80%	ND	ND	-	10	ND	ND	ND

ND : not detected.

2.5.2. S-2 (seawater)

The concentration of water samples for biological analyses conducted during the land-based testing of the BWMS was adjusted according to provisions in the Guidelines (G8). Table 2.6 gives water quality data. As shown in Table 2.7, the concentration of L-size group organisms (greater than or equal to 50μm in minimum dimension) in the test water was in the range between 117,187 and 181,283 inds/m^3, while the concentration of S-group organisms (greater than or equal to 10μm but less than 50μm in minimum dimension) in the test water was in the range between 1,144 and 1,589 inds/mL. As shown also in Table 2.7, the concentration of heterotrophic bacteria in the test water was in the range between 2.9 and 3.1 (x10^6 inds/mL). However, both the treated water (pre-treated upon the uptake) and the control water (not pre-treated upon the uptake) passed the criteria concerning the concentration of biological constituents as given by Regulation D-2 after being treated by the "FineBallast MF" BWMS.

Table 2.6. Water quality data from test S-2.

Date	Sample	pH	Temp. (°C)	Salinity (PSU)	DO (mg/L)	TSS (mg/L)	DOC (mg/L)	POC (mg/L)	Turbidity (NTU)
2010.06.23	Test water	8.2	24.7	32.3	6.5	20.1	2.3	1.4	3.74 (±0.06)
2010.06.28	Control	8.1	21.8	32.5	6.1	18.8	2.3	1.1	2.21 (±0.32)
2010.06.28	Treated	8.2	21.8	32.3	4.6	15.6	2.5	0.3	1.74 (±0.51)

Table 2.7. Biological efficacy of "FineBallast MF" from land-based test S-2.

Date	Sample	Sampling at	50μm< (inds,/m^3)	10~50μm (inds/mL)	Heterotro. Bacteria (inds/mL)	Heterotro. Bacteria (cfu/mL)	*E. coli* (cfu/100 mL)	*Vibrio cholerae* (cfu/100 mL)	*Entero coccus* (cfu/100 mL)
2010.06.23	Test water	20%	148,833	1,589	3.1E+06	660	195	ND	158
		50%	117,187	1,144	2.9E+06	380	193	ND	219
		80%	181,283	1,188	2.9E+06	313	223	ND	105
2010.06.28	Control	20%	1,700	117	-	293	97	ND	4
		50%	3,735	137	-	167	60	ND	17
		80%	6,710	114	-	100	63	ND	222
2010.06.28	Treated	20%	ND	ND	-	100	ND	ND	ND
		50%	ND	ND	-	63	ND	ND	ND
		80%	ND	ND	-	3	ND	ND	ND

2.5.3. S-3 (seawater)

The concentration of water samples for biological analyses conducted during the land-based testing of the BWMS was adjusted according to provisions in the Guidelines (G8). Table 2.8 gives water quality data. As shown in Table 2.9, the concentration of L-size group organisms (greater than or equal to 50μm in minimum dimension) in the test water was in the range between 120,267 and 238,520 inds/m^3, while the concentration of S-group organisms (greater than or equal to 10μm but less than 50μm in minimum dimension) in the test water was in the range between 971 and 1,183 inds/mL. As shown also in Table 2.9, the concentration of heterotrophic bacteria in the test water was in the range between 1.5 and 2.1 (x10^6 inds/mL). However, both the treated water (pre-treated upon the uptake) and the control water (not pre-treated upon the uptake) passed the criteria concerning the concentration of biological constituents as given by Regulation D-2 after being treated by the "FineBallast MF" BWMS.

Table 2.8. Water quality data from test S-3.

Date	Sample	pH	Temp. (°C)	Salinity (PSU)	DO (mg/L)	TSS (mg/L)	DOC (mg/L)	POC (mg/L)	Turbidity (NTU)
2010.09.29	Test water	8.2	22.6	32.4	7.0	25.8	2.8	1.8	5.11 (±1.27)
2010.10.04	Control	7.9	22.7	32.3	5.3	23.6	1.7	0.9	4.82 (±0.18)
2010.10.04	Treated	7.8	22.8	32.3	6.9	6.6	1.8	0.4	2.00 (±0.26)

Table 2.9. Biological efficacy of "FineBallast MF" from land-based test S-3.

Date	Sample	Sampling at	50μm< (inds/m^3)	10~50μm (inds/mL)	Heterotro. Bacteria (inds/mL)	Heterotro. Bacteria (cfu/mL)	*E. coli* (cfu/100 mL)	*Vibrio cholerae* (cfu/100 mL)	*Entero coccus* (cfu/100 mL)
2010.09.29	Test water	20%	238,520	1,103	1.5E+06	2,500	207	ND	9
		50%	151,083	971	1.7E+06	2,533	140	ND	47
		80%	120,267	1,183	2.1E+06	2,800	177	ND	32
2010.10.04	Control	20%	29,000	140	-	1,533	293	ND	199
		50%	28,014	132	-	1,300	227	ND	379
		80%	29,130	143	-	1,500	287	ND	486
2010.10.04	Treated	20%	ND	1	-	1,467	ND	ND	ND
		50%	ND	1	-	807	ND	ND	ND
		80%	ND	1	-	317	ND	ND	ND

2.5.4. S-4 (seawater)

The concentration of water samples for biological analyses conducted during the land-based testing of the BWMS was adjusted according to provisions in the Guidelines (G8). Table 2.10 gives water quality data. As shown in Table 2.11, the concentration of L-size group organisms (greater than or equal to 50μm in minimum dimension) in the test water was in the range between 135,150 and 245,000 inds/m^3, while the concentration of S-group organisms (greater than or equal to 10μm but less than 50μm in minimum dimension) in the test water was in the range between 996 and 1,521 inds/mL. As shown also in Table 2.11, the concentration of heterotrophic bacteria in the test water was in the range between 1.3 and 1.8 (x10^6 inds/mL). However, both the treated water (pre-treated upon the uptake) and the control water (not pre-treated upon the uptake) passed the criteria concerning the concentration of biological constituents as given by Regulation D-2 after being treated by the "FineBallast MF" BWMS.

Table 2.10. Water quality data from test S-4.

Date	Sample	pH	Temp. (°C)	Salinity (PSU)	DO (mg/L)	TSS (mg/L)	DOC (mg/L)	POC (mg/L)	Turbidity (NTU)
2010.10.13	Test water	7.9	21.9	32.3	7.2	18.8	3.2	2.0	3.17 (±0.13)
2010.10.18	Control	7.7	21.0	32.2	5.4	45.0	1.7	1.3	9.85 (±8.98)
2010.10.18	Treated	7.7	21.2	32.2	7.4	8.3	1.8	0.2	1.88 (±0.11)

Table 2.11. Biological efficacy of "FineBallast MF" from land-based test S-4.

Date	Sample	Sampling at	50μm< (inds/m^3)	10~50μm (inds/mL)	Heterotro. Bacteria (inds/mL)	Heterotro. Bacteria (cfu/mL)	*E. coli* (cfu/100 mL)	*Vibrio cholerae* (cfu/100 mL)	*Entero coccus* (cfu/100 mL)
2010.10.13	Test water	20%	245,000	996	1.8E+06	3,000	393	ND	35
		50%	174,080	1,041	1.3E+06	2,967	473	ND	283
		80%	135,150	1,521	1.5E+06	2,900	347	ND	25
2010.10.18	Control	20%	25,988	137	-	2,667	883	ND	469
		50%	26,730	121	-	3,233	907	ND	842
		80%	21,201	102	-	3,367	1,307	ND	2,013
2010.10.18	Treated	20%	ND	ND	-	823	ND	ND	ND
		50%	ND	ND	-	150	ND	ND	ND
		80%	ND	ND	-	87	ND	ND	ND

2.5.5. S-5 (seawater)

The concentration of water samples for biological analyses conducted during the land-based testing of the BWMS was adjusted according to provisions in the Guidelines (G8). Table 2.12 gives water quality data. As shown in Table 2.13, the concentration of L-size group organisms (greater than or equal to 50μm in minimum dimension) in the test water was in the range between 105,358 and 171,150 inds/m^3, while the concentration of S-group organisms (greater than or equal to 10μm but less than 50μm in minimum dimension) in the test water was in the range between 1,064 and 1,260 inds/mL. As shown also in Table 2.13, the concentration of heterotrophic bacteria in the test water was in the range between 1.1 and 1.3 (x10^6 inds/mL). However, both the treated water (pre-treated upon the uptake) and the control water (not pre-treated upon the uptake) passed the criteria concerning the concentration of biological constituents as given by Regulation D-2 after being treated by the "FineBallast MF" BWMS.

Table 2.12. Water quality data from test S-5.

Date	Sample	pH	Temp. (°C)	Salinity (PSU)	DO (mg/L)	TSS (mg/L)	DOC (mg/L)	POC (mg/L)	Turbidity (NTU)
2010.10.22	Test water	8.1	20.5	32.2	7.4	18.7	2.9	1.8	3.55 (±0.51)
2010.10.27	Control	8.0	18.0	32.2	5.6	20.9	1.5	1.5	4.85 (±0.25)
2010.10.27	Treated	8.0	18.1	32.2	8.1	7.4	1.7	0.5	1.58 (±0.76)

Table 2.13. Biological efficacy of "FineBallast MF" from land-based test S-5.

Date	Sample	Sampling at	50μm< (inds/m^3)	10~50μm (inds/mL)	Heterotro. Bacteria (inds/mL)	Heterotro. Bacteria (cfu/mL)	*E. coli* (cfu/100 mL)	*Vibrio cholerae* (cfu/100 mL)	*Enterococcus* (cfu/100 mL)
2010.10.22	Test water	20%	171,150	1,260	1.3E+06	1,933	489	ND	120
		50%	121,500	1,190	1.1E+06	2,533	317	ND	259
		80%	105,358	1,064	1.3E+06	2,033	356	ND	49
2010.10.27	Control	20%	16,748	111	-	1,733	1,039	ND	855
		50%	14,398	121	-	1,900	1,144	ND	1,337
		80%	16,896	96	-	1,833	1,200	ND	1,772
2010.10.27	Treated	20%	ND	1	-	453	ND	ND	ND
		50%	ND	ND	-	187	ND	ND	ND
		80%	ND	ND	-	153	ND	ND	ND

2.5.6. B-1 (brackish water)

The concentration of water samples for biological analyses conducted during the land-based testing of the BWMS was adjusted according to provisions in the Guidelines (G8). Table 2.14 gives water quality data. As shown in Table 2.15, the concentration of L-size group organisms (greater than or equal to 50μm in minimum dimension) in the test water was in the range between 126,000 and 154,475 inds/m^3, while the concentration of S-group organisms (greater than or equal to 10μm but less than 50μm in minimum dimension) in the test water was in the range between 1,162 and 1,425 inds/mL. As shown also in Table 2.15, the concentration of heterotrophic bacteria in the test water was in the range between 2.0 and 3.1 (x10^6 inds/mL). However, both the treated water (pre-treated upon the uptake) and the control water (not pre-treated upon the uptake) passed the criteria concerning the concentration of biological constituents as given by Regulation D-2 after being treated by the "FineBallast MF" BWMS.

Table 2.14 Water quality data from test B-1.

Date	Sample	pH	Temp. (°C)	Salinity (PSU)	DO (mg/L)	TSS (mg/L)	DOC (mg/L)	POC (mg/L)	Turbidity (NTU)
2010.07.07	Test water	8.4	24.5	21.1	7.3	54.0	5.8	5.9	18.2 (±1.23)
2010.07.12	Control	7.4	22.6	20.7	6.2	33.5	3.5	2.0	8.30 (±9.04)
2010.07.12	Treated	7.5	23.0	21.5	5.6	22.1	3.6	0.4	3.86 (±1.71)

Table 2.15 Biological efficacy of "FineBallast MF" from land-based test B-1.

Date	Sample	Sampling at	50μm< (inds/m^3)	10~50μm (inds/mL)	Heterotro. Bacteria (inds/mL)	Heterotro. Bacteria (cfu/mL)	*E. coli* (cfu/100 mL)	*Vibrio cholerae* (cfu/100 mL)	*Entero coccus* (cfu/100 mL)
2010.07.07	Test water	20%	154,475	1,425	3.1E+06	9,867	23	ND	310
		50%	126,000	1,377	2.0E+06	TNTC	15	ND	310
		80%	132,533	1,162	2.1E+06	TNTC	12	ND	240
2010.07.12	Control	20%	ND	153	-	13,653	287	ND	TNTC
		50%	13	166	-	12,587	277	ND	TNTC
		80%	2,800	142	-	15,467	317	ND	TNTC
2010.07.12	Treated	20%	ND	ND	-	107	3	ND	36
		50%	ND	ND	-	7	3	ND	63
		80%	ND	ND	-	0	3	ND	61

TNTC : too numerous to count

2.5.7.B-2 (brackish water)

The concentration of water samples for biological analyses conducted during the land-based testing of the BWMS was adjusted according to provisions in the Guidelines (G8). Table 2.16 gives water quality data. As shown in Table 2.17, the concentration of L-size group organisms (greater than or equal to 50μm in minimum dimension) in the test water was in the range between 128,863 and 154,000 inds/m^3, while the concentration of S-group organisms (greater than or equal to 10μm but less than 50μm in minimum dimension) in the test water was in the range between 1,015 and 1,743 inds/mL. As shown also in Table 2.17, the concentration of heterotrophic bacteria in the test water was in the range between 1.0 and 2.4 ($x10^6$ inds/mL). However, both the treated water (pre-treated upon the uptake) and the control water (not pre-treated upon the uptake) passed the criteria concerning the concentration of biological constituents as given by Regulation D-2 after being treated by the "FineBallast MF" BWMS.

Table 2.16. Water quality data from test B-2.

Date	Sample	pH	Temp. (°C)	Salinity (PSU)	DO (mg/L)	TSS (mg/L)	DOC (mg/L)	POC (mg/L)	Turbidity (NTU)
2010.07.21	Test water	8.4	26.6	21.7	6.5	74.4	7.0	5.2	19.0 (±1.00)
2010.07.26	Control	7.3	28.7	21.6	2.0	22.0	6.4	2.9	3.57 (±0.92)
2010.07.26	Treated	7.6	28.8	21.8	2.0	6.6	4.3	0.5	1.43 (±0.94)

Table 2.17. Biological efficacy of "FineBallast MF" from land-based test B-2.

Date	Sample	Sampling at	50μm< (inds/m^3)	10~50μm (inds/mL)	Heterotro. Bacteria (inds/mL)	Heterotro. Bacteria (cfu/mL)	*E. coli* (cfu/100 mL)	*Vibrio cholerae* (cfu/100 mL)	*Entero coccus* (cfu/100 mL)
2010.07.21	Test water	20%	154,000	1,743	1.5E+06	5,760	157	ND	146
		50%	129,165	1,719	1.0E+06	7,920	115	ND	61
		80%	128,863	1,015	2.4E+06	5,600	57	ND	59
2010.07.26	Control	20%	73,800	163	-	16,711	415	ND	TNTC
		50%	140,875	106	-	22,667	363	ND	TNTC
		80%	133,817	328	-	19,467	400	ND	TNTC
2010.07.26	Treated	20%	ND	ND	-	150	ND	ND	10
		50%	ND	ND	-	37	1	ND	10
		80%	ND	ND	-	573	ND	ND	8

2.5.8.B-3 (brackish water)

The concentration of water samples for biological analyses conducted during the land-based testing of the BWMS was adjusted according to provisions in the Guidelines (G8). Table 2.18 gives water quality data. As shown in Table 2.19, the concentration of L-size group organisms (greater than or equal to 50μm in minimum dimension) in the test water was in the range between 110,250 and 138,233 inds/m^3, while the concentration of S-group organisms (greater than or equal to 10μm but less than 50μm in minimum dimension) in the test water was in the range between 1,465 and 2,275 inds/mL. As shown also in Table 2.19, the concentration of heterotrophic bacteria in the test water was in the range between 1.5 and 2.8 (x10^6 inds/mL). However, both the treated water (pre-treated upon the uptake) and the control water (not pre-treated upon the uptake) passed the criteria concerning the concentration of biological constituents as given by Regulation D-2 after being treated by the "FineBallast MF" BWMS.

Table 2.18 Water quality data from test B-3.

Date	Sample	pH	Temp. (°C)	Salinity (PSU)	DO (mg/L)	TSS (mg/L)	DOC (mg/L)	POC (mg/L)	Turbidity (NTU)
2010.08.04	Test water	8.3	25.9	21.2	7.0	79.1	5.7	6.2	20.0 (±0.18)
2010.08.09	Control	7.4	27.7	21.2	2.2	17.4	2.9	3.6	2.50 (±0.16)
2010.08.09	Treated	7.4	28.1	21.4	2.4	5.9	3.5	0.5	1.05 (±0.49)

Table 2.19 Biological efficacy of "FineBallast MF" from land-based test B-3.

Date	Sample	Sampling at	50μm< (inds/m^3)	10~50μm (inds/mL)	Heterotro. Bacteria (inds/mL)	Heterotro. Bacteria (cfu/mL)	*E. coli* (cfu/100 mL)	*Vibrio cholerae* (cfu/100 mL)	*Entero coccus* (cfu/100 mL)
2010.08.04	Test water	20%	110,250	1,515	1.5E+06	36,800	103	ND	73
		50%	138,233	1,465	2.6E+06	42,267	47	ND	7
		80%	110,625	2,275	2.8E+06	31,733	47	ND	73
2010.08.09	Control	20%	87,433	97	-	35,733	207	ND	TNTC
		50%	53,650	108	-	38,933	260	ND	TNTC
		80%	78,000	121	-	42,667	373	ND	TNTC
2010.08.09	Treated	20%	ND	ND	-	93	ND	ND	ND
		50%	ND	ND	-	60	ND	ND	1
		80%	ND	ND	-	27	ND	ND	4

2.5.9.B-4 (brackish water)

The concentration of water samples for biological analyses conducted during the land-based testing of the BWMS was adjusted according to provisions in the Guidelines (G8). Table 2.20 gives water quality data. As shown in Table 2.21, the concentration of L-size group organisms (greater than or equal to 50μm in minimum dimension) in the test water was in the range between 104,535 and 116,708 inds/m^3, while the concentration of S-group organisms (greater than or equal to 10μm but less than 50μm in minimum dimension) in the test water was in the range between 1,841 and 3,809 inds/mL. As shown also in Table 2.21, the concentration of heterotrophic bacteria in the test water was in the range between 2.3 and 3.5 (x10^6 inds/mL). However, both the treated water (pre-treated upon the uptake) and the control water (not pre-treated upon the uptake) passed the criteria concerning the concentration of biological constituents as given by Regulation D-2 after being treated by the "FineBallast MF" BWMS.

Table 2.20 Water quality data from test B-4.

Date	Sample	pH	Temp. (°C)	Salinity (PSU)	DO (mg/L)	TSS (mg/L)	DOC (mg/L)	POC (mg/L)	Turbidity (NTU)
2010.08.18	Test water	8.3	26.4	21.4	7.3	56.3	6.2	6.2	17.6 (±1.16)
2010.08.23	Control	7.6	29.2	21.4	2.8	15.8	2.8	2.0	2.67 (±0.30)
2010.08.23	Treated	7.4	29.4	21.6	2.1	7.1	2.1	0.4	1.23 (±0.67)

Table 2.21 Biological efficacy of "FineBallast MF" from land-based test B-4.

Date	Sample	Sampling at	50μm< (inds/m^3)	10~50μm (inds/mL)	Heterotro. Bacteria (inds/mL)	Heterotro. Bacteria (cfu/mL)	*E. coli* (cfu/100 mL)	*Vibrio cholerae* (cfu/100 mL)	*Enterococcus* (cfu/100 mL)
2010.08.18	Test water	20%	116,708	3,809	2.9E+06	28,267	150	ND	7
		50%	104,535	3,108	2.3E+06	28,667	150	ND	27
		80%	113,400	1,841	3.5E+06	28,000	107	ND	7
2010.08.23	Control	20%	244	165	-	54,933	1,733	ND	TNTC
		50%	122	147	-	72,800	1,560	ND	TNTC
		80%	179	154	-	67,067	1,760	ND	TNTC
2010.08.23	Treated	20%	ND	ND	-	120	ND	ND	28
		50%	ND	ND	-	53	ND	ND	3
		80%	ND	ND	-	33	ND	ND	3

2.5.10.B-5 (brackish water)

The concentration of water samples for biological analyses conducted during the land-based testing of the BWMS was adjusted according to provisions in the Guidelines (G8). Table 2.22 gives water quality data. As shown in Table 2.23, the concentration of L-size group organisms (greater than or equal to 50μm in minimum dimension) in the test water was in the range between 97,920 and 125,935 inds/m^3, while the concentration of S-group organisms (greater than or equal to 10μm but less than 50μm in minimum dimension) in the test water was in the range between 1,021 and 1,261 inds/mL. As shown also in Table 2.23, the concentration of heterotrophic bacteria in the test water was in the range between 7.6 and 8.4 (x10^6 inds/mL). However, both the treated water (pre-treated upon the uptake) and the control water (not pre-treated upon the uptake) passed the criteria concerning the concentration of biological constituents as given by Regulation D-2 after being treated by the "FineBallast MF" BWMS.

Table 2.22 Water quality data from test B-5.

Date	Sample	pH	Temp. (°C)	Salinity (PSU)	DO (mg/L)	TSS (mg/L)	DOC (mg/L)	POC (mg/L)	Turbidity (NTU)
2010.09.01	Test water	8.3	27.3	20.5	7.2	59.4	5.5	5.3	18.6 (±0.86)
2010.09.06	Control	7.5	27.6	20.5	5.7	13.6	2.8	2.2	2.38 (±0.17)
2010.09.06	Treated	7.3	27.2	20.5	3.0	6.1	2.7	0.3	0.85 (±0.03)

Table 2.23 Biological efficacy of "FineBallast MF" from land-based test B-5.

Date	Sample	Sampling at	50μm< (inds/m^3)	10~50μm (inds/mL)	Heterotro. Bacteria (inds/mL)	Heterotro. Bacteria (cfu/mL)	*E. coli* (cfu/100 mL)	*Vibrio cholerae* (cfu/100 mL)	*Entero coccus* (cfu/100 mL)
2010.09.01	Test water	20%	117,500	1,084	8.4E+06	30,933	423	ND	68
		50%	97,920	1,261	7.6E+06	32,000	507	ND	80
		80%	125,935	1,021	7.6E+06	27,067	340	ND	37
2010.09.06	Control	20%	970	125	-	34,133	2,080	ND	676
		50%	2,238	145	-	32,533	1,600	ND	1,102
		80%	1,656	159	-	32,067	1,547	ND	1,067
2010.09.06	Treated	20%	ND	1	-	433	ND	ND	ND
		50%	ND	ND	-	173	ND	ND	2
		80%	ND	ND	-	73	ND	ND	2

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Annex 1. Species lists of organisms in the test water

Table 1. Species composition of test organisms greater than or equal to 10μm and less than 50μm in minimum dimension at S-1 (seawater).

BACILLARIOPHYCEAE	DINOPHYCEAE	CRYPTOPHYCEAE
Chaetoceros spp.	*Heterocapsa circularisima*	*Cryptomonas* spp.
Pseudo-nitzschia multistriata	*Prorocentrum dentatum*	
Thalassiosira eccentrica	*Scripsiella trochoidea*	CHLOROPHYCEAE
Thalassiosira spp.		*Tetraselmis* sp.
	EUGLENOPHYCEAE	
	Euglena spp.	

Table 2. Species composition of test organisms greater than or equal to 50μm or more in minimum dimension at S-1(seawater).

ARTHROPODA	**ANNELIDA**	**DINOPHYTA**
Artemia salina	polychaeta larvae	*Noctiluca scintillans*
Podon spp.		
Acarita omorii		
Acartia steueri		
Eurytemora pacifica		
Corycaeus affinis		
Oithona spp.		
copepodites of copepoda		
nauplii of copepoda		
nauplii of cirripedia		

Table 3. Species composition of test organisms greater than or equal to 10μm and less than 50μm in minimum dimension at S-2.

BACILLARIOPHYCEAE	*Ceratium lineatum*	CRYPTOPHYCEAE
Nitzschia spp.	*Heterocapsa rotundata*	*Cryptomonas* spp.
Thalassionema frauenfeldii	*Prorocentrum triestinum*	
		CHLOROPHYCEAE
DINOPHYCEAE	EUGLENOPHYCEAE	*Tetraselmis* sp.
Alexandrium spp.	*Eutreptiella gymnastica*	
Ceratium fusus		

Table 4. Species composition of test organisms greater than or equal to 50μm or more in minimum dimension at S-2.

ARTHROPODA	**ANNELIDA**	**DINOPHYTA**
Artemia salina	polychaeta larvae	*Noctiluca scintillans*
Oithona spp.		
Harpacticoid		
copepodites of copepoda		
nauplii of cirripedia		

Table 5. Species composition of test organisms greater than or equal to 10μm and less than 50μm in minimum dimension at S-3.

BACILLARIOPHYCEAE	*Thalassionema frauenfeldii*	CRYPTOPHYCEAE
Asterionella glacialis	*Thalassiosira nordensholdii*	*Cryptomonas* spp.
Chaetoceros curvisetus	*Skeletonema costatum*	
Chaetoceros decipiens	*Thalassiosira* spp.	EUGLENOPHYCEAE
Chaetoceros spp.		*Eutreptiella gymnastica*
Cylindrotheca closterium	DINOPHYCEAE	
Navicular spp.	*Scripsiella trochoidea*	CHLOROPHYCEAE
Nitzschia spp.		*Tetraselmis* sp.

Table 6. Species composition of test organisms greater than or equal to 50μm or more in minimum dimension at S-3.

ARTHROPODA	**MOLLUSCA**	**DINOPHYTA**
Artemia salina	bivalve larvae	*Noctiluca scintillans*
Paracalanus parvus s.l.		
Oithona spp.		
copepodites of copepoda		
nauplii of copepoda		
nauplii of cirripedia		
ANNELIDA		
polychaeta larvae		

Table 7. Species composition of test organisms greater than or equal to 10μm and less than 50μm in minimum dimension at S-4.

BACILLARIOPHYCEAE	*Nitzschia* spp.	CHRYSOPHYCEAE
Chaetoceros affinis	*Proboscia alata*	*Dictyocha fibula*
Chaetoceros curvisetus	*Rhizosolenia* sp.	
Chaetoceros decipiens	*Thalassiosira* spp.	CRYPTOPHYCEAE
Chaetoceros didymus		*Cryptomonas* spp.
Eucampia zodicus	DINOPHYCEAE	
Guinardia striata	*Ebria tripartita*	CHLOROPHYCEAE
Navicular spp.	*Peridinium* spp.	*Tetraselmis* sp.

Table 8. Species composition of test organisms greater than or equal to 50μm or more in minimum dimension at S-4.

ARTHROPODA	**ANNELIDA**	**DINOPHYTA**
Artemia salina	polychaeta larvae	*Noctiluca scintillans*
Paracalanus parvus s.l..		
Oithona spp.		
copepodites of copepoda		
nauplii of cirripedia		

Table 9. Species composition of test organisms greater than or equal to 10μm and less than 50μm in minimum dimension at S-5.

BACILLARIOPHYCEAE	*Pseudo-nitzschia pungens*	CHRYSOPHYCEAE
Chaetoceros affinis	*Rhizosolenia* sp.	*Dictyocha fibula*
Chaetoceros compressus	*Skeletonema costatum*	*Dictyocha speculum*
Chaetoceros danicus	*Thalassionema frauenfeldii*	
Coscinodiscus sp.	*Thalassiosira decipiens*	CHLOROPHYCEAE
Ditylum brightwellii		*Tetraselmis* sp.
Eucampia zodicus	DINOPHYCEAE	
Guinarida delicatula	*Alexandrium* spp.	
Hemialus hauckii	*Gymnodinium* spp.	

Table 10. Species composition of test organisms greater than or equal to 50μm or more in minimum dimension at S-5.

ARTHROPODA	**MOLLUSCA**	**DINOPHYTA**
Artemia salina	bivalve larvae	*Noctiluca scintillans*
Paracalanus parvus s.l..		
Oithona spp.		
copepodites of copepoda		
nauplii of copepoda		
nauplii of cirripedia		

Table 11. Species composition of test organisms greater than or equal to 10μm and less than 50μm in minimum dimension at B-1.

BACILLARIOPHYCEAE	*Skeletonema costatum*	*Protoperidinium pellucidum*
Amphipora sp.	*Thalassionema frauenfeldii*	*Prorocentrum triestinum*
Chaetoceros vanheurckii		
Cylindrotheca closterium	DINOPHYCEAE	CHLOROPHYCEAE
Guinarida delicatula	*Heterocapsa* sp.	*Tetraselmis* sp.
Pseudo-nitzschia spp.	*Prorocentrum dentatum*	

Table 12. Species composition of test organisms greater than or equal to 50μm or more in minimum dimension at B-1.

ARTHROPODA	**ANNELIDA**	**DINOPHYTA**
Artemia salina	polychaeta larvae	*Noctiluca scintillans*
Podon spp.		
Oithona spp.		
Harpacticoid		
nauplii of copepoda		
nauplii of cirripedia		

Table 13. Species composition of test organisms greater than or equal to 10μm and less than 50μm in minimum dimension at B-2.

BACILLARIOPHYCEAE	*Nitzschia* spp.	*Prorocentrum micans*
Chaetoceros affinis	*Thalassionema frauenfeldii*	
Chaetoceros compressus		CHRYSOPHYCEAE
Chaetoceros debilis	DINOPHYCEAE	*Dictyocha fibula*
Chaetoceros spp.	*Ceratium fusus*	
Cylindrotheca closterium	*Ceratium lineatum*	CHLOROPHYCEAE
Leptocylindrus danicus	*Dinophyceae accumulate*	*Tetraselmis* sp.

Table 14. Species composition of test organisms greater than or equal to 50μm or more in minimum dimension at B-2.

ARTHROPODA	**ANNELIDA**	**DINOPHYTA**
Artemia salina	polychaeta larvae	*Noctiluca scintillans*
Penilia avirostris		
Paracalanus parvus s.l.		
Oithona spp.		
Harpacticoid		
copepodites of copepoda		
nauplii of copepoda		
nauplii of cirripedia		

Table 15. Species composition of test organisms greater than or equal to 10μm and less than 50μm in minimum dimension at B-3.

BACILLARIOPHYCEAE	*Nitzschia* sp.	CRYPTOPHYCEAE
Chaetoceros affinis		*Cryptomonas* spp.
Chaetoceros compressus	DINOPHYCEAE	
Chaetoceros debilis	*Prorocentrum micans*	CHLOROPHYCEAE
Cylindrotheca closterium		*Tetraselmis* sp.
Eucampia zodicus		

Table 16. Species composition of test organisms greater than or equal to 50μm or more in minimum dimension at B-3.

ARTHROPODA	**MOLLUSCA**	**DINOPHYTA**
Artemia salina	bivalve larvae	*Noctiluca scintillans*
Evadne tergestina	gastropoda larvae	
Penilia avirostris		
Podon spp.		
Acarita omorii		
Acartia sp.		
Paracalanus parvus s.l.		
Pseudodiaptomus marinus		
Oithona spp.		
Harpacticoid		
nauplii of cirripedia		

Table 17. Species composition of test organisms greater than or equal to 10μm and less than 50μm in minimum dimension at B-4.

BACILLARIOPHYCEAE	*Pseudo-nitzschia pungens*	DINOPHYCEAE
Chaetoceros affinis	*Skeletonema costatum*	*Alexandrium* spp.
Chaetoceros debilis	*Synedra* sp.	*Nematodinium sp.*
Chaetoceros laciniosus	*Thalassionema nitzschioides*	*Scripsiella trochoidea*
Cylindrotheca closterium	*Thalassiosira* spp.	
Guinarida delicatula		CHLOROPHYCEAE
Nitzschia spp.	CRYPTOPHYCEAE	*Tetraselmis* sp.
Pleurosigma spp.	*Cryptomonas* spp.	

Table 18. Species composition of test organisms greater than or equal to 50μm or more in minimum dimension at B-4.

ARTHROPODA	**MOLLUSCA**	**DINOPHYTA**
Artemia salina	bivalve larvae	*Noctiluca scintillans*
Penilia avirostris		
Oithona spp.		
nauplii of cirripedia		
ANNELIDA		
polychaeta larvae		

Table 19. Species composition of test organisms greater than or equal to 10μm and less than 50μm in minimum dimension at B-5.

BACILLARIOPHYCEAE	*Ceratium fusus*	CRYPTOPHYCEAE
Chaetoceros decipiens	*Ceratium* sp.	*Cryptomonas* spp.
Navicular spp.	*Heterocapsa circularisima*	
Pseudo-nitzschia multistriata	*Heterocapsa rotundata*	RAPHIDOPHYCEAE
Thalassiosira spp.	*Prorocentrum minimum*	*Chattonella* spp.
	Scripsiella trochoidea	
DINOPHYCEAE		CHLOROPHYCEAE
Ceratium furca		*Tetraselmis* sp.

Table 20. Species composition of test organisms greater than or equal to 50μm or more in minimum dimension at B-5.

ARTHROPODA	**ANNELIDA**	**DINOPHYTA**
Artemia salina	polychaeta larvae	*Noctiluca scintillans*
Evadne tergestina		
Paracalanus parvus s.l.		
Corycaeus affinis		
Oithona spp.		
copepodites of copepoda		
nauplii of copepoda		
nauplii of cirripedia		

Annex 2. Certificate of Accreditation

Annex 2.1 Certificate of Accreditation for ISO/IEC 17025

Name of Laboratory :	Korea Ocean Research and Development Institute (KORDI)
Date :	11th June 2007
Administrator :	Korea Laboratory Accreditation Scheme (KOLAS) Governmental accreditation body in the Republic of Korea

※The ISO/IEC 17025 System were executed from October 2006 at KORDI in field of bio-efficacy test for type approval test of ballast water management system.

Annex 2.2 Designation of Type Approval Testing Body

Name of Laboratory :	Korea Ocean Research and Development Institute (KORDI)
Date :	29th August 2007
Administrator :	Ministry of Maritime Affairs & Fisheries (MOMAF)
Regulation :	Provisional Regulation of Type Approval of Ballast Water Management System (2006-77, MOMAF, 8th November 2006)

※According to the retroactive to Provisional Regulation of Type Approval of Ballast Water Management System (2006-77, MOMAF), the test results which conducted before designation identified as type approval test.

Annex 2.1 Certificate of Accreditation for ISO/IEC 17025

No. 322 (1/2)

CERTIFICATE OF ACCREDITATION

Name of Laboratory : Korea Ocean Research and Development Institute

Representative : Yum, Ki-Dai

Address of Headquarters : 1270, Sa2-dong, Ansan, 426-744, Korea

Address of Laboratory : 391 Jangmok-ri, Jangmok-myon, Geoje-si, 656-830, Korea

Duration : June 11, 2007 ~ June 10, 2011

Scope of Accreditation
(Scope of Accreditation is described in the accompanying Annex)

This is to certify that the above Laboratory is accredited as Testing Laboratory in accordance with the provisions of Article 23 of the National Standards Act.

These criteria encompass the requirements of ISO/IEC 17025 : 2005.

June 11, 2007

Administrator,
Korea Laboratory Accreditation Scheme(KOLAS)

No. 322 (2/2)

9. Biological testing

9.006 Aquatic biology

Test method	Standard designation
APHA-804C : 1985	American Public Health Association (APHA)/Standard methods for the examination of water and wastewater/To ascertain if a motionless animal is dead, touch it gently with a sealed glass capillary probe
EPA-445.0 : 1997	Environmental Protection Agency (EPA)/In vitro determination of chlorophyll-*a* and pheophytin *a* in marine and freshwater algae by fluorescence

End.

Annex 2.2 Designation of Type Approval Testing Body (Korean)

지정번호 제1호
Cert. No. 1

밸러스트수관리시스템 형식승인시험기관 지정서
Certificate of Accreditation as the Type Approval Test Organization of Ballast Water Management System

지정을 받는 자 Nominee	①명 칭(상 호) Name of Organization	한국해양연구원 Korea Ocean Research & Development Institute		
	②성 명(대표자) Representative	염기대 Yum, Ki-Dai	③주민등록번호 (법인등록번호) ID No	490906-1000525 (130122-0002126)
	④주 소(사업장) Address	대한민국 경기도 안산시 사동 1270 1270, Sa-dong, Ansan-si, Gyonggi-do, Korea (경상남도 거제시 장목면 장목리 391번지, 391, Jangmok-ri, Jangmok-myon, Geoje-si, Korea)		
⑤형식승인시험의 종류 Scope of Accreditation		육상시험 및 선상시험 Land-based testing and shipboard testing		

「밸러스트수관리시스템의 형식승인 등에 관한 잠정기준」 제6조제3항에 따라 이 지정서를 교부합니다.

This is to certify that the above Body is accredited as a Type Approval Test Organization in accordance with the Interim Regulation for Type Approval of Ballast Water Management System and IMO MEPC Res. 125(53).

2007년 8월 29일
August 29, 2007

해 양 수 산 부 장 관
Minister of Ministry of Maritime Affairs and Fisheries